FIFTY YEARS OF MARS SURFACE AND ATMOSPHERIC COMPOSITION FROM TELESCOPES: HIGHLIGHTS AND IMPLICATIONS FOR SPACECRAFT STUDIES.

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The modern era of Mars telescopic studies began shortly after World War II, with Gerard Kuiper's spectroscopic discovery of CO_2 in the Martian atmosphere. Other early studies included measurements of Martian water vapor, searches for infrared spectral features from organics, discovery of hydrated mineral absorption features in the near-infrared, and characterization of the detailed visible-wavelength spectral reflectance properties of the surface materials. Improvements in telescopes and detectors over the years have yielded associated improvements in spatial and spectral range, resolution, and SNR. This talk will review a number of important findings that have come from these studies, including both atmospheric composition and surface mineralogy. Also discussed will be more recent findings and controversies, especially on surface mineralogy, that have come from even higher spectral resolution near-IR telescopic observations and higher spatial resolution HST observations.

A common theme among the telescopic observations is that increased spatial resolution provides for increased spectral heterogeneity. On broad regional scales, spectral variability is muted by the presence of fine-grained and relatively spectrally-bland surface and airborne dust. On finer spatial scales, however, telescopic observations can "see through" this dust in small areas (tens to hundreds of km) where local bedrock or local soil deposits are visible, and detect more spectral diversity. The fact that even from Earth telescopic observations can detect subtle variations in ferric oxide, pyroxene, and hydrated mineral absorption features bodes well for future visible and near-IR spacecraft global spectroscopic investigations like MARCI (this optimism is borne out in part by the evidence for spectral variability seen even in the poorly-spectrally-sampled Viking Orbiter color imaging data and the small and spatially-limited Phobos-2 ISM dataset).

There have been many fewer infrared telescopic studies of Mars, but even these have been able to detect some spectral variability, especially when imaging at high spatial resolution. This bodes well for future (current) high spatial resolution spacecraft infrared studies like MGS/TES, which will hopefully detect much more infrared spectral variability during its systematic mapping mission. Fewer specific minerals have been identified or proposed based on infrared telescopic observations compared to visible and near-IR observations, however, and this represents a challenge for infrared instruments. While there is great potential to detect a number of important primary and secondary mineral phases from infrared observations, extracting this unique information from a complex emissivity signature that includes the atmosphere and surface dust/coatings over a range of temperatures is not straightforward. Many of the same problems are encountered at the shorter reflected light wavelengths, of course, but relatively mature surface and atmospheric radiative transfer modeling has allowed purely surface constituents to be identified. It will be interesting to see in the coming year if TES is able to also uniquely identify many different surface mineralogic constituents through similar modeling efforts.

The history of modern telescopic observations has revealed that spectral diversity exists on Mars at fine spatial scales, and that both visible/near-IR and IR techniques can detect this variability. Ultimately, there is little value in debating whether reflectance observations or emissivity observations are "best", because both offer advantages for different types of surface studies. Just as it has been important to seek the truth about Martian surface and atmospheric composition using both reflectance and emissivity techniques from telescopic observations, it will be important to measure both of these spectral domains from spacecraft in Martian orbit. TES provides the first opportunity for global mapping spectroscopic observations in the infrared, to be followed up by higher spatial resolution IR imaging from THEMIS. Hopefully a similar opportunity for high spatial resolution visible/near-IR spectroscopy will become available (perhaps OMEGA?) to complement the high spatial resolution visible/near-IR imaging studies to be performed next year by MARCI. The combination of global measurements across the entire spectral domain will ultimately strengthen our ability to interpret the observations in terms of unique surface mineralogic components.